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Charlie Cowell

University of Northern Iowa

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The Built Environment's Effect on Obesity in the United States

Charlie Cowell

ABSTRACT. Obesity is a growing concern in the United States. Obesity results from eating more calories than one's body can use as energy per day. To lose weight one must either eat fewer calories or use more energy. Some suggest that certain public amenities may encourage healthy lifestyles. Others suggest public amenities have no effect on personal activity levels. This paper looks at the influence the built environment has on obesity rates in U.S. cities. An Ordinary Least Squares regression model is used and finds that significant characteristics of the built environment include acres of parkland, number of recreation facilities, commute times, and active travel rates in a city.

I. Introduction

A planner's objective is to improve the welfare of people and their communities by creating more convenient, equitable, healthful, efficient, and attractive places for present and future generations (APA 2011). A growing topic in planning is the design of healthy communities. City planners across the U.S. work to create opportunities for people to lead healthy lifestyles. The design of the built environment is one tool planners can use. In general, the built environment consists of anything that does not occur in nature. From the first civilization until now, city design has become more complex. Today the built environment consists of buildings, streets, city parks, trails, parking lots, and anything else one would find within a city's limits.

Obesity rates are a specific health concern in the U.S. The current research asks whether the built environment is a factor contributing to obesity in the United States. Obesity rates in different cities can provide insight into whether people actually use public amenities that encourage physical activity if they are available. A number of factors can lead to obesity, but cities that do not provide adequate healthy amenities could see a rise in obesity rates.

II. Obesity in the United States

Obesity is measured according to the body mass index. Body mass index is calculated as body weight in pounds divided by height in inches

squared, times a conversion factor of 703. A body mass index over 30 is considered obese and a body mass index over 25 is considered overweight. In the United States, obesity rates have risen substantially in the past ten years. Mississippi had the highest obesity rate of all states in 2000 at 25%. In 2009, Mississippi still had the highest obesity rate, but it increased to 34.4%. Increases occurred in every state between 2000 and 2009. Obesity can lead to many other diseases such as cardiovascular disease, stroke, high blood pressure, and diabetes (Center for Disease Control and Prevention 2011).

Obesity results from consuming more calories than can be used as energy. Certain diseases and genetics can also contribute to obesity. Aside from genetic factors, two things can prevent obesity: consume fewer calories or use more energy. Evidence suggests that moderate physical activity, such as brisk walking most days of the week, can provide health benefits, especially in the reduction of cardiovascular disease and diabetes (Haennel and Lemire 2002). Exercise in addition to moderate daily activity can further minimize the chance of becoming overweight or obese (Blair et al. 2004). A pedestrian-friendly community with resources that promote physical activity can be one step to help prevent obesity. Land use mix and density could also be important to provide easy access to healthy food options.

III. Urban Design and Active Travel

Urban design is the arrangement, appearance, and functionality of cities. A built environment that is strategically designed allows its elements to be used efficiently by citizens. For instance, the location of residential districts next to commercial districts provides households with the opportunity to travel short distances for their daily necessities.

Active transportation is one element affected by the built environment and can help fight obesity. Active transportation includes walking, bicycling, and using public transit. To actively travel one must engage in some form of physical activity, even if done with low intensity. Public transportation is included in active travel because one would likely have to walk or bike to a pick-up location to access it (Bassett 2008). Non-active travel includes things that do not require physical activity, such as driving a personal vehicle, car-pooling with others, or using a taxi.

IV. Literature Review

Research suggests that health problems, particularly obesity, are influenced by the built environment. Suggestions on what should be done are often given, but little research provides empirical evidence to support the suggested changes to the built environment.

To find evidence that suggests the built environment can influence obesity, one can examine countries with different city structures. Most European cities, for example, were built before automobiles were available. As a result, European cities are compact and pedestrian friendly. Active travel is more widely used in Europe than in the U.S. Urban trips on a bike in the U.S. make up only 1% of travel, compared to 12% in Germany and 28% in the Netherlands. In addition, the percent of urban trips taken by foot in the U.S. are only 8.6%, compared to 24% in France and 29% in Sweden (Boone 2006). Weather would seem to play a factor in active travel, but the statistics disagree. Countries with temperatures colder than the U.S. have much higher active travel rates. Other explanations Boone (2006) suggests are that Europeans have a better tolerance for cyclists, better trails, and a higher cost of car ownership.

Differences in active transportation rates among countries lead some to blame the built environment. Public transportation and land use policies could explain some of the difference between active travel in Europe and the U.S. Pucher et al. (2010) say that cycling and walking infrastructure improvements should be combined with restrictions on car use to increase active travel. Improvements could include things that protect pedestrians such as sidewalks, bike lanes, and intersection modifications.

To see the effect that international differences in active travel have on obesity rates, Bassett (2008) did a cross-sectional study including Europe, North America, and Australia. He found that areas with higher active travel rates have lower obesity rates. He also found that countries with higher rates of car use also have higher obesity rates. The study provides some evidence that active transportation may influence obesity rates across countries.

A built environment that encourages active travel is not the only design factor thought to reduce obesity rates. Recent research by Zhao and Kaestner (2010) provides evidence that the amount of urban sprawl (measured by population density) in a city could modestly increase

obesity rates. Their model looks at changes in urban sprawl and obesity rates from 1970-2000 using a two-step instrumental variables approach. They conclude that a one percent decrease in the share of population living in dense areas increased the prevalence of obesity by 0.1–0.2 percent.

Social factors may also play a role in obesity rates. With data collected by a telephone survey, Brownson (2001) found many social factors that are important. The support of community members could entice one to be more physically active. Neighborhoods where people can be seen exercising, having a friend who encourages exercise, or having at least one friend to exercise with, can affect physical activity levels. People may be self-conscious about exercising in public open space, so access to gyms and recreation centers can be important. Brownson (2001) also concluded that neighborhood crime does not have a significant influence on physical activity levels, whether through exercise in public open space or at nearby facilities. Other social factors that may influence activity include low income individuals and racial characteristics (Cutts et al. 2009).

Research on individual cities could help find specific built environment factors that contribute to unhealthy lifestyles. The Atlanta, Georgia region provides one example. Frank et al. (2004) gathered data from a travel survey of 10,000 people in the region. A logistic regression was used with the data to test the effect specific urban design elements have on obesity. The regression controlled for age, education, and household income. Geographical Information Systems (GIS) is used to measure factors such as street connectivity and land use mix. Land use mix had the strongest association with obesity. In addition, an increase in one hour of time spent driving per day is associated with a 6% increase in the likelihood of obesity. An increase in one kilometer of walking per day showed a 4.8% reduction in the likelihood of obesity. Frank's et al. (2004) conclusion is only for the Atlanta region but could be an example of similar trends across U.S. cities.

V. Methodology

The purpose of this paper is to discover if the built environment affects obesity in the United States. Several characteristics in the built environment may affect obesity rates in a city. Four factors are

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considered in the research: urban sprawl, recreation facilities, active transportation, and commute time. The dependent variable is the percentage of people that are overweight or obese in each city. Variables for age, race, income, and weather are included to account for other factors that may affect overweight and obesity rates.

The age variable measures the average age of residents in each city. Race variables measure the percent of the population that is African-American and the percent of the population that is Hispanic in each city. The income variable measures the median household income in each city. Data for age, race, and income are taken from the U.S. Census Bureau. The weather variable measures the number of undesirable days per year in a city. Undesirable days include the average number of days with a temperature above 90 degrees Fahrenheit or with a temperature below 32 degrees Fahrenheit. Weather data are taken from weatherbase.com, which compiles statistics for yearly weather averages in cities from the National Climatic Data Center.

The first built environment variable measures urban sprawl as the population density of each city's urbanized area. There is not a universal way to measure urban sprawl. Cities evaluate urban sprawl in different ways, which makes it hard to identify the best measure. Low population density is only one characteristic of urban sprawl. Other important factors include the neighborhood mix of homes, jobs, and services, the strength of activity centers and downtowns, and the accessibility of street networks (Ewing et al. 2002). Population density could be important because a dense area will allow people to actively travel to accomplish daily activities. They could walk to grocery stores, schools, and community events easily because of shorter distances between points. When population densities are higher, car dependency decreases. A higher population density also promotes a mixed land use because commercial districts can be located closer to residential districts. Data for population density are taken from the U.S. Census Bureau.

The second group of built environment variables measures the availability and quality of resources that promote physical activity. The number of recreation facilities in each city represents the availability of resources. Recreation facilities include recreation centers, ball diamonds, basketball courts, playgrounds, swimming pools, tennis courts, park units, ice skating rinks, and dog parks. Various types of recreation facilities

were included to address the different ways in which people prefer to be physically active. Availability also includes the amount of parkland in a city. A city with many small parks could result in overcrowding. People may be more willing to use parks that provide adequate space to be active. Parkland area is measured in two different ways, the total parkland as a percent of city area and the acres of parkland for every 1,000 people.

Just because a city provides parks does not necessarily mean that people will use the parks. Parks that are run down and crime ridden may deter people from using them. To measure the quality of city parks, a variable for park related expenditures per capita is included. The more money spent per person on parkland should indicate that more services are used to keep parks clean and safe in a city. All of the data for availability and quality of resources are taken from the Trust for Public Land's Center for City Park Excellence. The acres of parkland for each city are compiled by the Center for City Park Excellence based on the parks within city limits. The Center for City Park Excellence provides data for the number of different recreation facilities within city limits. Rural area parks outside city limits are not included.

A third built environment variable measures the active travel rate for work commutes. A higher number of people that actively commute should indicate that the built environment favors active transportation. The active travel variable includes the percent of people in the city that walk, bike, or use public transit to go to work. Data for active transportation are from the U.S. Census Bureau.

The final built environment variable measures the time people spend commuting each day. The variable is meant to account for the amount of car dependency in each city. One problem is that the data include time spent commuting by active transportation, as well as by non-active transportation. Active travel rates are a small percentage in each sample city, so the majority of commute time is still by non-active transportation. More time spent commuting results in less leisure time. People with less leisure time will be less likely to devote time to physical activity. Reduced leisure time may also leave people with less time to cook healthy meals at home. Persons with long commutes may choose fast-food options on their way to and from work to save time. In addition, more time spent in an automobile means more time sitting each day, which contributes to a sedentary lifestyle. Data for the average commute time

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per day are taken from the U.S. Census Bureau. An Ordinary Least Squares regression model is used to test each variable's influence on overweight and obesity rates in U.S. cities.

VI. Anticipated Results

The variables for age and race are predicted to be positively related to obesity. As the average age of residents and the African-American/Hispanic population of a city increases, the higher the obesity rate will be. Older people tend to be overweight because of physical characteristics, such as joint problems, that prevent them from participating in physical activity. Metabolism also decreases as with age, which means less food will be used as energy during the day. A higher African-American or Hispanic population may lead to a higher obesity rate because studies show that African-Americans and Hispanics tend to be more obese than other races (Center for Disease Control and Prevention 2011). The variable for income is predicted to be inversely related to obesity rates. Households with higher incomes have more money to spend on healthier food options and higher quality recreational resources such as gyms, golf memberships, and exercise equipment for their homes. People with higher incomes may be more educated on the dangers of obesity and the preventative steps that can be taken against obesity. The variable for weather is predicted to be positively related to obesity rates. Weather conditions could affect if people choose to actively travel or use outdoor recreation facilities. Days with poor weather conditions would entice people to drive to destinations or to not go outside at all. Poor weather conditions in a city would make it harder for people to be physically active.

The variable for urban sprawl is predicted to be positively related to obesity rates. As a city experiences more urban sprawl, the obesity rate will be higher. A sprawling city causes people to live farther from daily necessities. A trip to the grocery store, to pick kids up from school, or to work requires one to drive. Time spent traveling for daily errands results in less time to be physically active. Active travel may not be an option in sprawling cities.

All of the variables for the availability and quality of recreational facilities are predicted to be inversely related to the obesity rate in a city. As the number of facilities, the acres of parkland, and the park

expenditures in a city increase, the obesity rate will decrease. More recreational facilities in a city will make it easier for residents at different locations to access facilities. A city with more parkland per person will have less crowded and more enjoyable parks. A higher level of park expenditures per person means that a city provides quality parks that people will want to use. Each of the variables encourages people to be physically active, so the obesity rate will tend to be lower.

The percent of people who commute by active transportation is predicted to be inversely related to the obesity rate in a city. The more people that actively travel in a city will result in lower obesity rates for that city. Moderate physical activity 5 days a week for 30 minutes may reduce the chance of becoming obese. By walking or biking to work, people may achieve the moderate level of activity recommended per week. A high number of people who actively travel may also indicate that the built environment complements pedestrians and bicyclists.

The variable for time spent commuting each day is predicted to be positively related to the obesity rate in a city. The more time people spend commuting, the higher the obesity rate will be. Longer commute times indicate that people spend more time in their car each day and will have less leisure time. People will be reluctant to spend the leisure time they do have for physically activity.

VII. Model

The Ordinary Least Squares regression model uses a sample of 50 randomly chosen cities in the United States. The 50 cities are drawn from the 85 most populated cities in the U.S. because parkland and recreation data are only available for the 85 most populated cities. Anchorage, Alaska is one of the top 85 most populated cities, but it is omitted from the sample because its parkland area data has significant outliers. Because many of the cities occupy multiple counties, the county that contains the central city is used to gather data for some variables. All of the data are taken for the year 2009. The equation used to model the influence each variable has on a city's overweight and obesity rate is shown as:

$$\text{FAT} = \alpha + \beta_1(\text{BLACK}) + \beta_2(\text{C}) + \beta_3(\text{PRKRES}) + \beta_4(\text{ACTIVE}) + \beta_5(\text{TRVTIM}) + \beta_6(\text{RECFAC})$$

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Where:

- FAT = Percent of people in the city's central county that are overweight or obese
- BLACK = Percent of the population in the city's central county that are African-American
- INCOME = Median household income of the city's central county
- PRKRES = Acres of parkland per 1,000 residents in the city
- ACTIVE = Percent of people that commute to work on foot, bicycle, or public transit.
- TRVTIM = Average travel time in minutes per day for each city's central county.
- RECFAC = Number of recreation facilities per 100,000 residents in the city

Several variations of the model were run to achieve the current results. Heteroskedasticity and multicollinearity were analyzed and did not occur in the model. Natural logs of all the variables were tested to account for possible nonlinear relationships. None of the variables seemed to exhibit nonlinear relationships.

Some variables explained in the methodology are not included in the final model. Age was predicted to be positively related to obesity rates. The average age of each city's residents is not significant in the model and the signs of the coefficients are inconsistent. The variables for total park expenditures per resident and Hispanic population are omitted for the same reason as the average age variable. Park expenditure in a city was predicted to be inversely related to the obesity rate. The variable is not significant.

The weather variable was omitted from the final model and was not significant in any of the models run. The measurement used for weather conditions may not be the appropriate measure. For example, the number of days in a year that are below 32 degrees Fahrenheit can be misleading. A temperature of 30 degrees in Minneapolis, Minnesota could be an acceptable condition to walk to work or be physically active outside (skiing, ice skating, etc.). A temperature of 30 degrees in Houston, Texas, however, would cause many people to drive to work and to stay indoors. Other measures need to be tested before one can suggest that weather does not influence overweight and obesity rates in a city.

A measure for urban sprawl is the last variable omitted. As said before, urban sprawl is measured as the population density of each city's urbanized area. When included, the significance of other variables would fall. There may be some multicollinearity between population density and other variables, although it was not apparent when multicollinearity tests were run. A dense city will likely have more people that actively travel to work. Travel times to work will also tend to be lower in a dense city because commercial and residential districts are closer together. Therefore, a city's population density (urban sprawl) may be associated with the active travel and the average commute time variables.

VIII. Descriptive Statistics

The descriptive statistics for the data are shown in Table 1. The variables show a wide range of values. The average overweight and obesity rate of all cities in the sample is 62.18%. San Francisco, California has the lowest rate at 44.80% and Memphis, Tennessee has the highest rate at 72.80%. San Francisco also has the highest percent of people who commute by active travel of all cities in the sample at 44.60%. A reason for the higher active travel rate could be the public transit system used in San Francisco. 32.4% of residents in San Francisco report using public transit to commute each day. The highest number of recreation facilities per 100,000 residents is Cincinnati, Ohio at 311.10. The lowest number is Phoenix, Arizona at 54.20.

TABLE 1—Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
<i>Dependent Variable:</i>				
Overweight/Obese Percentage	62.18%	5.23%	44.80%	72.80%
<i>Independent Variables:</i>				
Percent African-American	18.63%	13.72%	1.20%	51.20%
Median Household Income	\$50,786	\$9,900	\$34,801	\$85,215
Parkland per 1,000 Residents	17.27 acres	13.08 acres	2.30 acres	67.50 acres
Percent Who Commute by Active Travel	8.66%	7.68%	1.30%	44.60%
Avg. Commute Time per Day	24.27 min.	3.25 min.	17.60 min.	31.50 min.
Total Recreation Facilities per 100,000	142.81	56.12	54.20	311.10
N = 50 samples				

IX. Results

The results of the OLS regression are shown in Table 2. All of the variables are significant in explaining the overweight and obesity rate in a city. Median household income, acres of parkland per 1,000 residents, active travel rates, and the total recreation facilities per 100,000 residents in a city are statistically significant at the 1% level. The percent of African-American population and average commute time per day in a city are statistically significant at the 5% level. The model has an adjusted r-square of .7897.

TABLE 2—OLS Regression Results

Variable	Estimated Coefficient	T-Ratio	P-Value
<i>Dependent Variable:</i>			
Overweight/Obese Percentage (FAT)			
<i>Independent Variables:</i>			
Percent African-American (BLACK)	0.08012	2.566	0.014**
Median Household Income (INCOME)	-0.00026	-5.701	0.000***
Parkland per 1,000 Residents (PRKRES)	-0.08433	-2.871	0.006***
Percent who Commute by Active Travel (ACTIVE)	-0.39090	-6.690	0.000***
Avg. Commute Time per Day (TRVTIM)	0.36661	2.553	0.014**
Total Recreation Facilities per 100,000 (RECFAC)	-0.01985	-3.143	0.003***
Constant	72.461	17.89	0.000***
**Significant at the 5% level	N = 50	R = 0.815	ADJ
***Significant at the 1% level			R²=0.7897

Each variable's relationship with a city's overweight and obesity rate coincides with the previous predictions. The percent of residents who are African-American and the average commute time per day are positively related to unhealthy weights. As each variable increases in a city, the overweight and obesity rate will increase. The median household income,

acres of parkland per resident, active travel rate, and total recreation facilities in a city are inversely related to unhealthy weights. With an increase in each variable, the overweight and obesity rate will decrease.

The model shows some of the characteristics of healthy cities. A high-density city with adequate park space and recreation facilities will have a lower percentage of residents who are overweight or obese. Higher densities give people the opportunity to walk or bike to work and reduce driving time for those who choose to drive. Public transit systems tend to be used more in large, dense cities. Cities that provide facilities that promote physical activity are important to reduce overweight and obesity rates. The model suggests that people will participate in healthy activities if they are provided.

With an adjusted r-square of .7897, the model has much more explaining power than anticipated. In addition to promoting physical activity, some of the variables may indirectly affect eating habits. Households with higher incomes can afford healthy, high quality food options if they choose. People who actively travel to work may not have time to leave work during lunch breaks. Instead, they may bring food with them rather than go out to eat for lunch. Lastly, people who spend less time traveling to work may have more time to devote to healthy meal options. Instead of getting fast food on the way to and from work, people with more time may elect to cook meals at home.

Two things should be considered when interpreting the results of the model. First, not everyone resides in a city for an extended period of time. It takes time for a person who lives an unhealthy lifestyle to become overweight. There is a constant movement of people from city to city based on economic conditions and personal preferences. Because of changes in where people reside, the built environment may not have a long term effect on all residents in a city.

Second, the amenities provided by a city could affect the type of people who choose to reside in that city. Charles Tiebout formulated a theory called "Tiebout Sorting" to explain how people choose where to live. According to Tiebout, a person's choice of where to live is affected by the amenities and public goods provided by a local government. People will move to a community that provides the public goods they prefer and are willing to pay for. Households essentially "vote" for the public goods they want a city to provide by moving to where the public goods are located (Tiebout 1956). Tiebout Sorting could affect the overweight and obesity rate in cities across the U.S. People who prefer

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healthy lifestyles may choose to live in a city that provides healthy amenities. Therefore, the built environment would not affect the weight of people already living in a city. The built environment would either attract healthy people to a city or detract healthy people away from a city.

X. Conclusion

Obesity results from eating more calories than one's body can use as energy per day. To prevent obesity one must eat fewer calories or use more energy throughout the day. Other factors can contribute to obesity. The built environment is one factor that can influence obesity rates across the United States. This paper suggests that some built environment characteristics affect overweight and obesity rates. Public amenities such as parkland and recreation facilities are significant. Population density factors, including active travel rates and average commute times, are also significant to explain obesity across U.S. cities.

In further research it may be necessary to look at where overweight people reside in a particular city. Cities are not homogenous and the built environment varies throughout a city. If planners can identify which areas in a city have more overweight residents, then the design of the built environment in these areas can be targeted. Changes made to the built environment could encourage and enable people to develop healthy lifestyles. Geographical Information Systems (GIS) are useful tools for further research. Regressions run with GIS software can help city planners identify specific census blocks where the built environment influences obesity.

The results suggest that U.S. cities should provide certain public amenities in order to promote healthy lifestyles for their citizens. Urban planners need to consider many design elements in order to create healthy communities. Dense cities, with a diverse land use mix, may be beneficial to reduce obesity. Incorporating the suggested characteristics into city planning will help improve the welfare of communities across the United States.

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